

**Technical Documentation to Support Development of  
Minimum Flows and Levels for the Caloosahatchee  
River and Estuary**

## **Appendix C**

**Impacts of Freshwater Inflows on the Distribution of  
Zooplankton and Ichthyoplankton in the  
Caloosahatchee Estuary, Florida**

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## **Impacts of Freshwater Inflows on the Distribution of Zooplankton and Ichthyoplankton in the Caloosahatchee Estuary, Florida**

by

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### **Introduction**

An average monthly freshwater inflow of 300 cfs has been established as the minimum flow and level (MFL) to protect the upstream freshwater-brackish plant, *Vallisneria americana* (Figure 1), from high salinity exposure during the dry season (MFL Document – SFWMD 2000). A maximum discharge limit of 2,800 cfs has been recommended to protect downstream seagrass from being adversely impacted by low salinity conditions (Chamberlain and Doering 1998a, b; Doering et al. 2002). Expert reviewers of the MFL document suggested that further investigation was needed to understand how the above-recommended inflows influence other biota in the Caloosahatchee Estuary. This summary paper highlights the results of two data analysis efforts, previously presented as posters (Chamberlain et al. 1999, 2001), with the following goals: (1) characterize the spatial and seasonal abundance of zooplankton and ichthyoplankton as it relates to freshwater inflow; (2) specifically assess the potential influence of above-recommended discharges on these components of the plankton community; and (3) determine inflows that tend to maximize abundance.

### **Methods**

Paired 0.5 mm conical zooplankton nets with a 243 micron mesh were obliquely towed from the stern of a 20' boat. Another pair of nets with a 505-micron mesh was concurrently deployed from a side boom to collect ichthyoplankton. The ichthyoplankton nets also proved successful at collecting fish eggs, shrimp, and crab larvae. A flow meter was affixed in the mouth of one zooplankton and one ichthyoplankton net. Nocturnal samples were collected monthly at six (6) stations (Figure 1) and a seventh station in Pine Island Sound every other month during 1986-1989. Zooplankton only samples were again collected during abnormally high freshwater inflows in 1998. Net samples were identified to the lowest taxonomic level possible. Repetitive samples of zooplankton in the water column were also collected with a bilge pump in 1988-1989 at stations 1, 2, 4, 5 during low to moderate inflows, and again during high inflows in 1994 -1996 and 1998. A fixed volume was filtered through a 60-micron mesh and individual zooplankton

were sorted into major groups and enumerated. Freshwater inflow volume through S-79 was measured daily throughout the year. Water quality, including salinity, was sampled during each trip.

## Results

### Zooplankton

There were 108 invertebrate taxa collected during the 1986-1989 zooplankton net sampling. The copepod, *Acartia tonsa* comprised 52% of the total density. In the pump samples, copepod nauplii and all other copepod stages constituted 67% of the zooplankton, contributing 45% and 22% respectively. Over 90% of the crab and shrimp larvae in the ichthyoplankton nets were *Minippe mercenaria* (stone crabs). *Penaeus* sp. comprised approximately 7% and *Callinectes* sp. accounted for approximately 2%.

In general, mean zooplankton density (net samples) increased with increasing distance from S-79. Statistical differences, as judged by a multiple range test, are shown in Figure 2 (bottom). The greatest zooplankton density occurred at higher salinity stations (> 20ppt) farthest from S-79. A similar trend appeared for the pump samples, however not as strongly, with station 5 supporting the least zooplankton density.

Stations 5 and 6 accounted for over 99% of the shrimp and crab larvae enumerated in the ichthyoplankton nets. The peak abundance occurred at station 6 where salinity was nearly the highest. Blue crab larvae (*Callinectes sapidus*) require salinity above 20 ppt, demonstrating the importance of establishing a maximum discharge limit for station 6.

There were apparent differences in density between seasons at each station during both pump and net sampling (Figure 3). This was most evident in the pump samples, with the period of April – July being the most productive, followed by December – March. Zooplankton density was lowest during the rainiest portion of wet season, August – November. A similar, but less evident seasonal influence can be seen in the net samples. The same order of seasonal ranking appears (April – July and December – March > the August – November), but only at stations 3, 4, and 5. Seasonal influences become less clear at the estuarine boundaries.

Inflow volume appears to be more of an influence than salinity. Density decreases as inflows increase at most stations for both pump and net samples, as shown in Figure 4. In zooplankton net samples, inflows that exceed 1,500 cfs and approach 3,000 cfs or greater are associated with the lowest zooplankton density, except at the farthest downstream stations (6 and 7).

In zooplankton net samples, the average density for all stations combined were further separated into 6 inflow categories and tested for significant differences (Figure 5). Optimal inflows associated with the highest zooplankton densities occurred in the 150-600 cfs range. Flows higher or lower than this were associated with lower densities. Inflows that approach and exceed 1,200 cfs supported the least zooplankton density.

Again in the zooplankton net samples, the same 6 flow categories were used to examine the influence of freshwater input at each station (Figure 6). Except at station 6, the same general trend appears for most stations as was seen when flow was examined for all stations combined. Inflows that approach and exceed 2,500 cfs were associated with the least zooplankton; and inflows in the 2nd and usually 3rd categories (151 - 600 cfs) always supported the greatest density of zooplankton.

### **Ichthyoplankton**

Average monthly discharges from S-79 ranged from 69 to 4,510 cfs during 1986-1989 (Figure 7). These inflows were highly variable between months and years. Average discharge was < 1,000 cfs during January through June, but approached 2,000 cfs during the remaining six months. High variability in discharge resulted in wide fluctuations in salinity, with a range >20 ppt (Figure 8) at Stations 3, 4, and 5.

Five fish families contributed > 1% to the total fish abundance. Engraulidae, Gobiidae, Sciaenidae, Clupeidae and Blennidae accounted for approximately 96% of the total abundance. *Anchoa mitchelli* was the dominant single species comprising 54% of the number of fish collected. Fish egg composition was dominated by Engraulids, with Sciaenids also making a significant contribution.

As with inflow and salinity, the average ichthyoplankton density was highly variable between stations (Figure 9). The distribution pattern generally followed that of *Anchoa*. The median

density followed the longitudinal salinity distribution as did average density to a lesser extent. Significant differences between stations also followed the median values. Station 6 was associated with the greatest density, station 5 ranked 2nd, and Station 2 was associated with the lowest density. The density of fish eggs generally followed the same patterns of distribution and significance as the ichthyoplankton.

The average ichthyoplankton density was greater for most of the estuary during the spring months, March through June (Figure 10). This is when inflow is usually lower (Figure 7). The high density at Station 3 during November through February was primarily due to a high abundance of *Anchoa mitchelli* that occurred late in February 1986. High ichthyoplankton density occurred during July through October only at Station 6. During this time period, discharges are usually greater (Figure 7). It is likely that Station 6 offers better salinity conditions for most species than upstream when discharges are high.

Average egg density is also greatest during spring, for both Engraulids and Sciaenids (Figure 11). November through February produced the 2nd highest abundance. Anchovies prefer spawning upstream of Shell Point at Stations 4 and 5 during the dry season, November – June. As with ichthyoplankton, Engraulid egg density (Figure 11a) increases downstream at station 5 and 6 during the wet season, July – October. Average Sciaenid egg density (Figure 11b) also was greatest during spring, but remained high at Station 6 during this season, compared to declining trend of Engraulid eggs. Sciaenids generally seem to prefer spawning farther down stream in higher salinity water, which is especially evident as seasonal freshwater inflows increased during the wet season.

Analysis of data at each station determined that when inflows were < 600 cfs, ichthyoplankton density was significantly greater at Stations 3, 4, and 5. The same was true for eggs, except at Station 2, where inflows < 600 cfs also were associated with greater density. No significant differences in densities associated with inflows were found at the remaining stations.

During the dry season (November – June) is when the estuary is most likely to suffer a lack of minimum flows to support upstream submerged plants, but also most threatened by large Lake Okeechobee regulatory releases. When the dry season was examined separately during this

analysis, inflows that exceeded 2,500 cfs were associated with the lowest ichthyoplankton and egg density and inflows < 600 cfs had greater densities.

Inflows were consistently lower during the spring months of 1989 than during 1987 and 1988. Since spring is the most productive time in the estuary, extra sampling was conducted in March and April during each of these three years. During 1987 and 1988 freshwater inflows averaged 1,836 and 1,854 cfs, while in 1989 the mean inflow was 433 cfs. In 1989, ichthyoplankton density was greater in the estuary, especially upstream of Shell Point (Figure 12). More of the estuary also was used for spawning during 1989 (Figure 13). This suggests that lower flows favor increased utilization of the estuary.

## **Conclusion**

### **Zooplankton**

Mean zooplankton density increased along with salinity and distance from S-79. The late spring to early summer season is generally when zooplankton density is greatest, just prior to the wet season's heaviest rainfall runoff during August to November when density is lowest. High freshwater inflows and lower salinity drive zooplankton down regardless of the season. Zooplankton were weakly related to salinity, but correlated well with freshwater inflow volume, possibly due to a "wash out" effect.

Some freshwater inflow is important to the estuary in order for zooplankton to achieve maximum density. At most stations, except those farthest downstream (6 and 7) the greatest densities were measured when inflows range was 150-600 cfs. Except at station 6, inflows that exceed 1,200-1,500 cfs were associated with reduced zooplankton density. Inflows that were greater than 2,500-3,000 cfs supported the lowest density.

Ninety percent of the shrimp and crab larvae were collected at station 5 and 6, with the peak abundance occurring at station 6, when salinity exceeded 20-25 ppt. Therefore inflows that normally do not exceed 2,500 -3,000 cfs will protect the San Carlos Bay spawning and rearing area. Inflows that remain below 1,200-1,500 cfs will also provide habitat upstream of Shell Point.

## Ichthyoplankton

Freshwater inflows < 600 cfs were associated with the highest ichthyoplankton and egg density. The maximum ichthyoplankton utilization of the estuary and spawning occurred in more areas during low flows. Ichthyoplankton and eggs were greatest during the dry season, especially in spring. Dry season and spring minimum inflows necessary to protect upstream SAV will not adversely impact ichthyoplankton and egg abundance. Inflow < 600-800 cfs, associated with higher seagrass production near Station 5 (Doering et al. 2002), should also maximize ichthyoplankton and egg abundance in this region and downstream.

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- South Florida Water Management District (SFWMD). 2000. Technical document to support development of minimum flows and levels for the Caloosahatchee River and Estuary.

## FIGURES

Figure 1. Plankton sampling stations and locations of submerged vegetation found upstream of Shell Point in the Caloosahatchee Estuary, southwest Florida.

Figure 2. Average zooplankton density per station and the corresponding mean salinity during net sampling. Letters associated with net samples summarize results of a multiple range test examining potential differences between stations. Bars with different letters are significantly different ( $p < 0.05$ ).

Figure 3. Average zooplankton density at each station compared to seasonal differences.

Figure 4. Influence of freshwater inflow through S-79 on zooplankton density at downstream estuary stations.

Figure 5. Effect of freshwater inflow through structure S-79 on net collected zooplankton density. Letters summarize results of a multiple range test examining potential differences between inflow categories. Bars with different letters are significantly different ( $p < 0.05$ ).

Figure 6. Effect of freshwater inflow through structure S-79 on net collected zooplankton density at six downstream stations. Letters summarize results of a multiple range test examining potential differences between inflow categories. Bars with different letters are significantly different ( $p < 0.05$ ).

Figure 7. Average monthly freshwater inflows from S-79 during sampling. Inflows grouped together in two-month intervals. Inflow range and median for each interval indicated.

Figure 8. Salinity distribution at each sampling station during ichthyoplankton sampling. Salinity range and median value indicated.

Figure 9. Average and median ichthyoplankton density at each station during the entire period of sampling. Average salinity at each station also indicated. The number above the bars is the coefficient of variation. Bars with different letters are significantly different ( $p < 0.05$ ).

Figure 10. Average ichthyoplankton and coefficient of variation (CV) at sampling stations during three seasons.

Figure 11. Average fish egg density at sampling stations during three seasons for: (a) Engraulids and (b) Sciaenids.

Figure 12. Average ichthyoplankton density at each sampling station during three consecutive spring seasons experiencing different freshwater inflow conditions.

Figure 13. Average fish egg density at each sampling station during three consecutive spring seasons experiencing different freshwater inflow conditions.

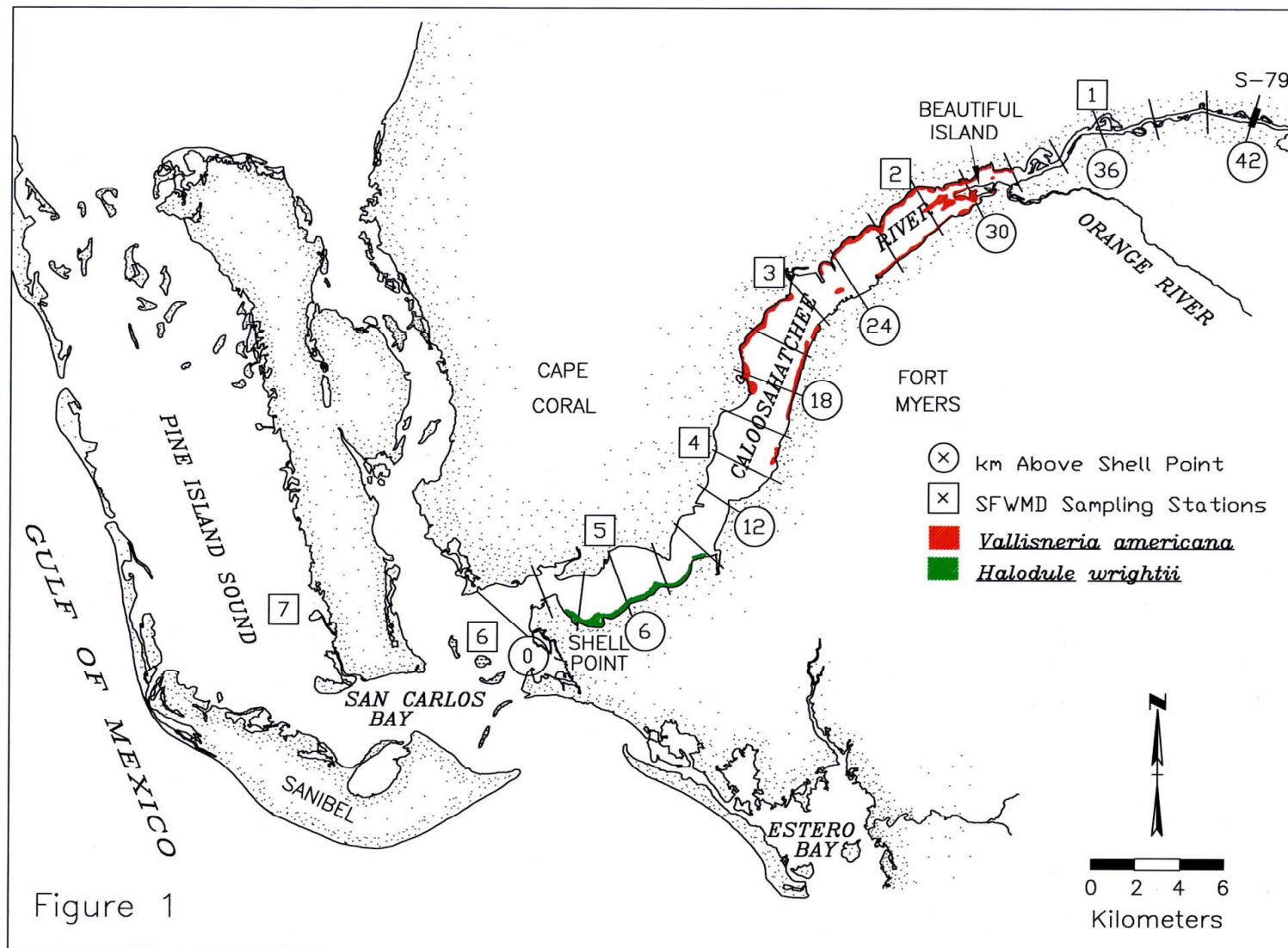


Figure 1

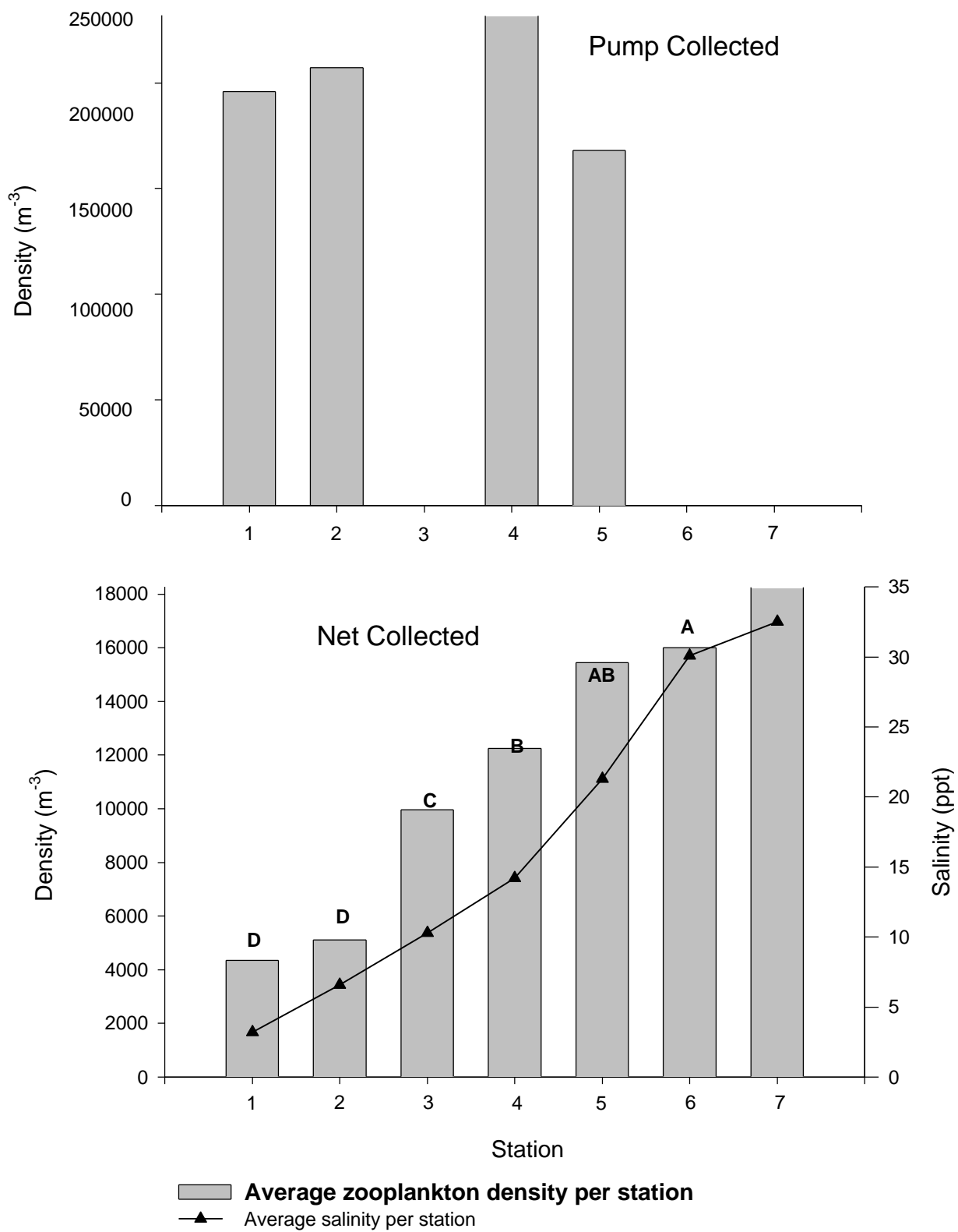


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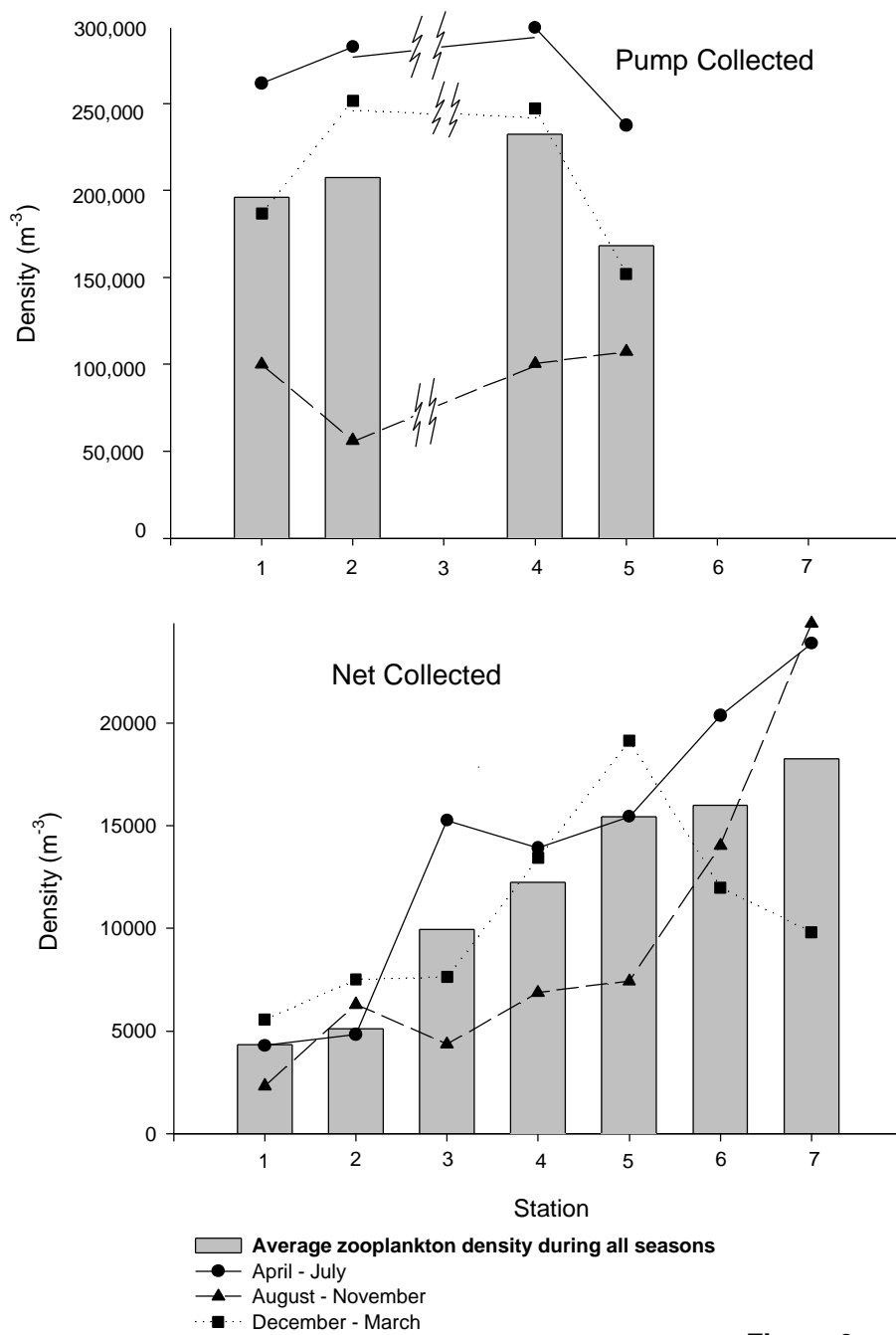


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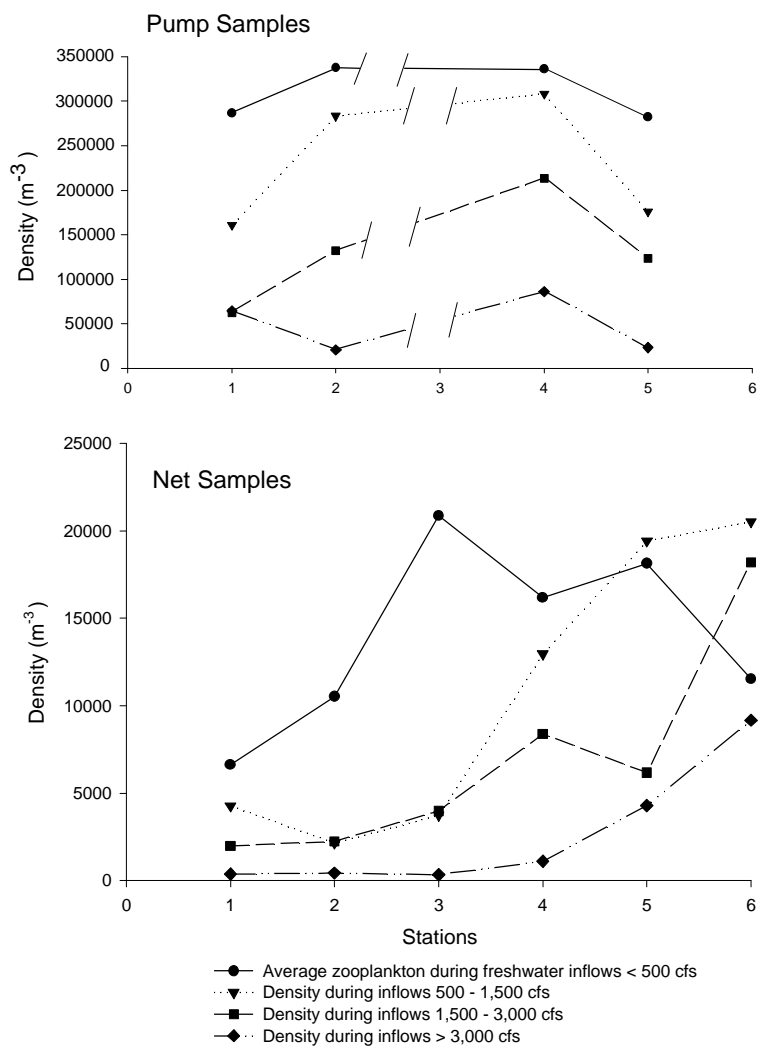


Figure 4

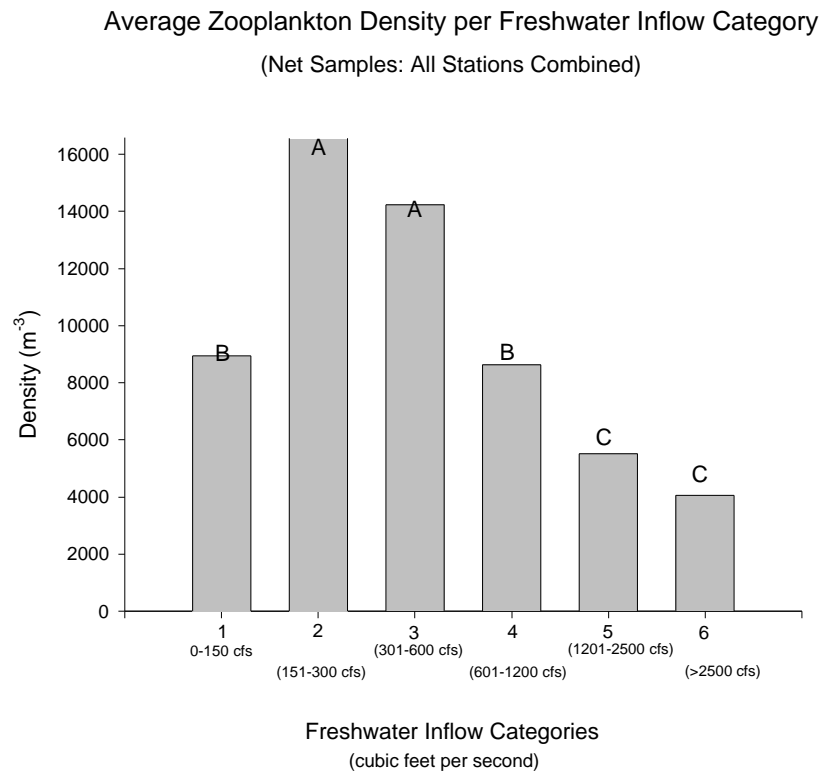


Figure 5

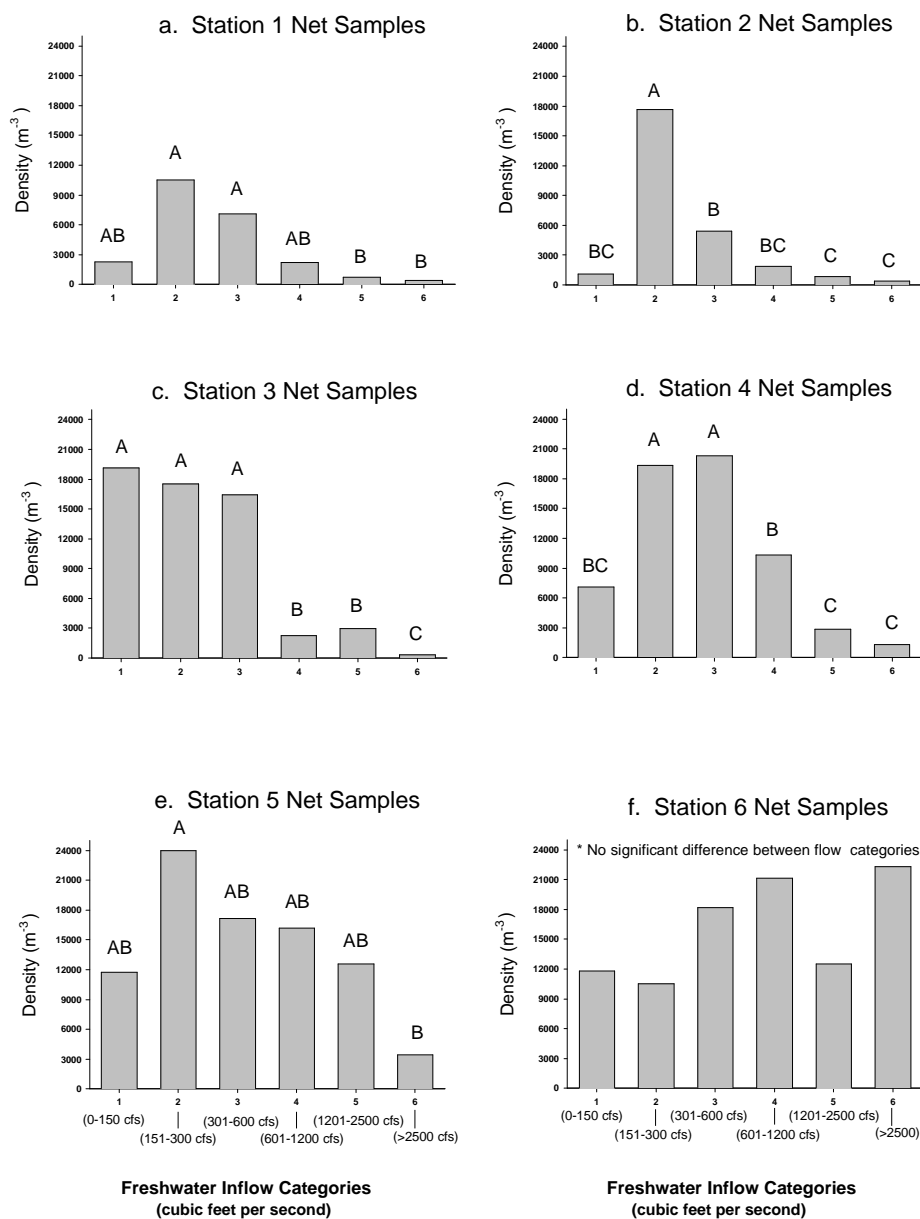


Figure 6

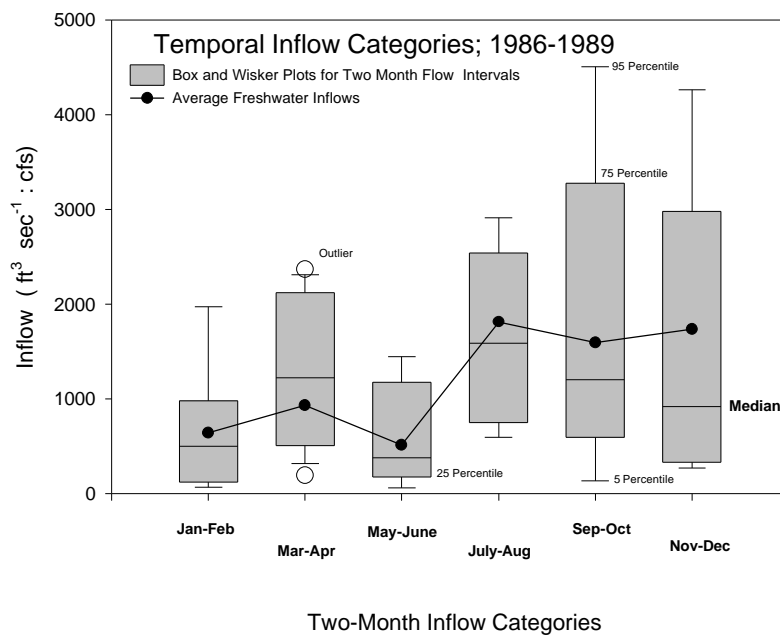


Figure 7

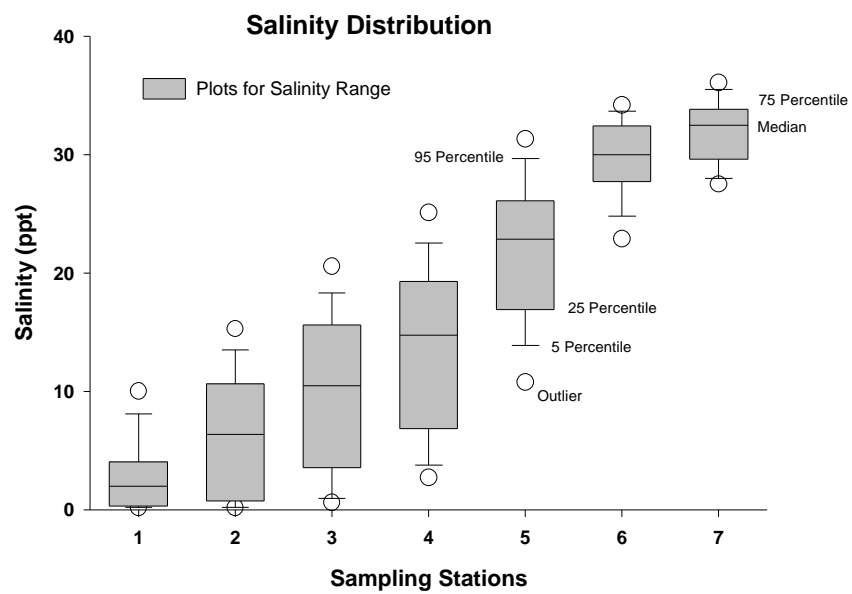


Figure 8

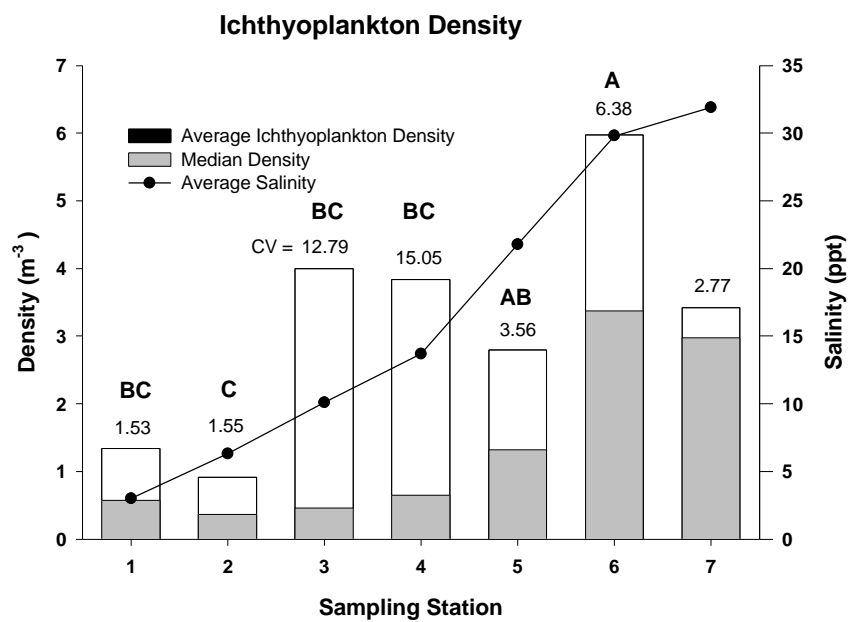


Figure 9

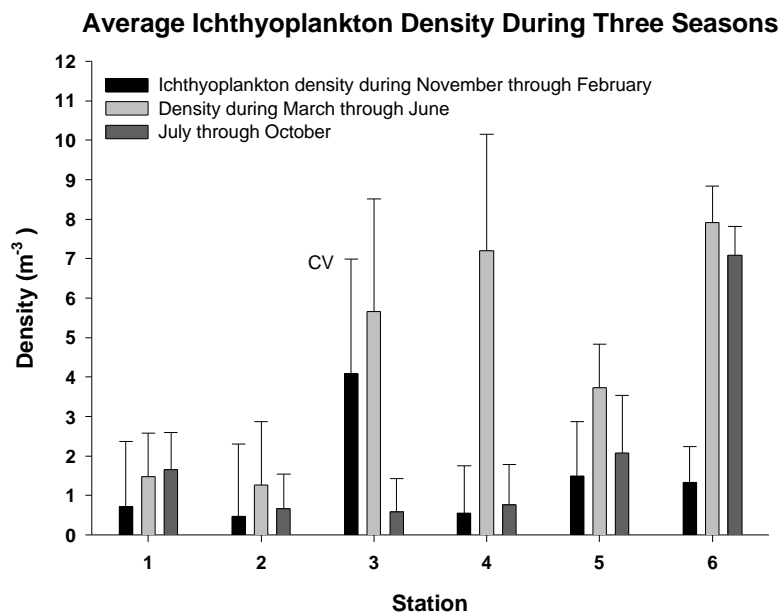


Figure 10

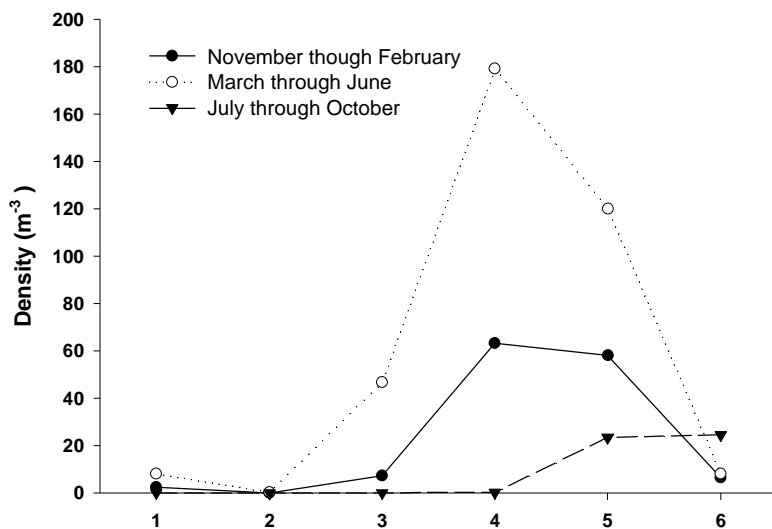
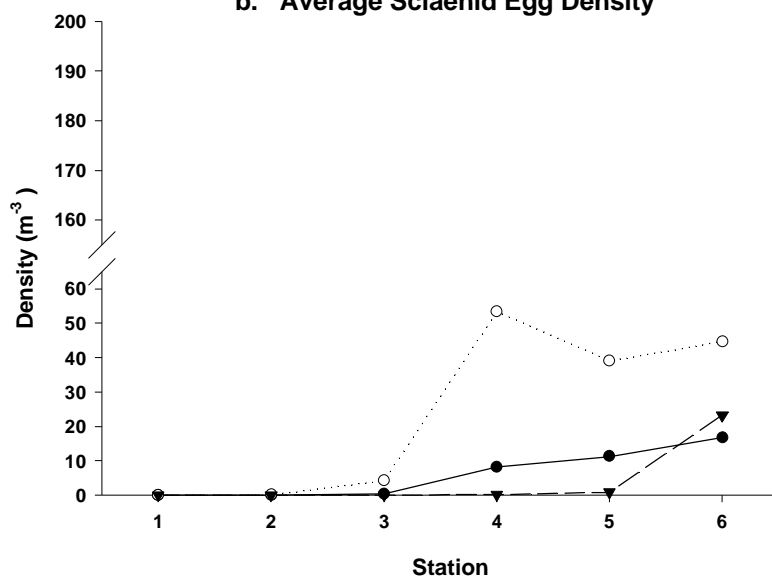
**a. Average Engraulid Egg Density****b. Average Sciaenid Egg Density**

Figure 11

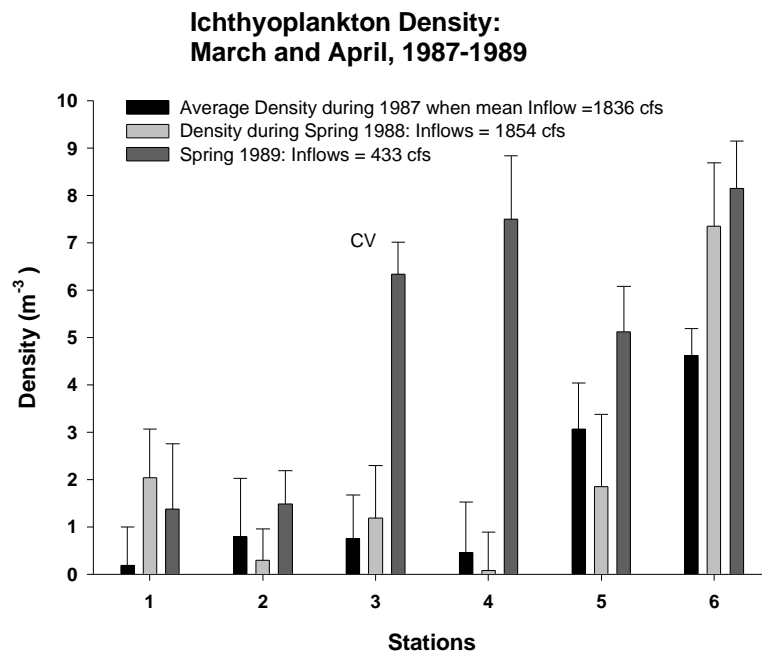


Figure 12

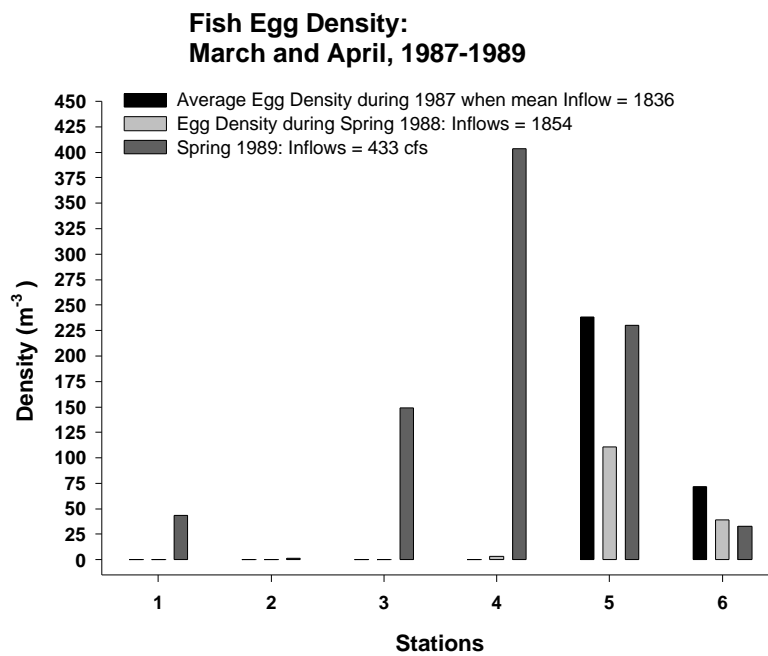


Figure 13